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GEOTHERMAL ACTIVITIES IN CENTRAL AMERICA

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by

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ABSTRACT

The Agency for International Development is funding a new program in energy and minerals for Central America. Geothermal energy is an important component. A country-wide geothermal assessment has started in Honduras, and other assessment activities are in progress or planned for Costa Rica, El Salvador, Guatemala, and Panama. Instrumentation for well logging has been provided to Costa Rica, and a self-contained logging truck will be made available for use throughout Central America. An important objective of this program is to involve the private sector in resource development.

INTRODUCTION

On February 8, 1985, M. Peter McPherson, Administrator of the Agency for International Development, and Senator Pete Domenici announced a new AID-funded program titled "Central American Energy and Mineral Development: A Path Toward Economic Security." The countries included are Costa Rica, El Salvador, Guatemala, Honduras, Panama, and, as appropriate, countries of the Caribbean. The program is coordinated and managed by Los Alamos National Laboratory. Initial funding is $10.2 million. It is expected to be a multi-year program. The objectives are to

- increase economic development and employment in Central America,
- provide a means for the private sector to develop energy and mineral resources, and
- provide training to counterpart scientists and engineers.

The resources targeted for assessment are geothermal, peat, and minerals. Some attention will also be given to coal and lignite; petroleum and natural gas; and wind, solar, and biomass. This program will not undertake resource development. That is a job for the private sector.

Much of the work on this project will be done by Los Alamos scientists, engineers, and economists. As appropriate, consultants will be utilized from the private sector, other laboratories, and universities. The U.S. Geological Survey is contributing to the overall program, particularly in the geothermal and minerals projects. The following discussion centers on geothermal activities that are part of this program.

PILOT PROJECT ON ST. LUCIA

This program was preceded by a geothermal project on St. Lucia, in the West Indies. Before 1983, attempts to assess and develop the geothermal resource had been made by British, Italian, and U.S. consulting firms. However, no production wells were drilled. In 1983, Los Alamos was funded by the Trade and Development Program of the U.S. Department of State to assess the resource and recommend drilling sites.

St. Lucia is a volcanic island. Steam fumaroles and boiling pools occur near the town of Soufriere within the Qualibou caldera, which formed 32,000 to 39,000 years ago. Regional linear faults and caldera faults appear to control the location of thermal springs within the caldera.

A 5.2-km-long dipole-dipole DC resistivity survey was conducted along a north-south trending line through the caldera (Fig. 1). An apparent resistivity high, greater than 1000 ohm-m, is located below the Belfond area. Beneath this high there is deeper low-resistivity material that is less than 10 ohm-m. A zone of very low apparent resistivity, less than 1 ohm-m, underlies the Etangs area. This zone is related to thermal upwelling along what is probably the caldera-bounding fault (Fig. 2).

Beneath Sulphur Springs at a depth of approximately 600 m is higher apparent resistivity material ranging from 40 ohm-m up to 150 ohm-m in the center of a 1-km-diameter high-resistivity closure. These data strongly suggest a very hot dry steam field.

Hydrogeochemical data from Qualibou caldera indicate a geothermal reservoir underlies the Sulphur Springs area that consists of (1) an upper steam condensate zone, (2) an intermediate vapor zone, and (3) a lower brine zone. Temperatures as high as 212°C were measured at a depth of 600 m during previous shallow drilling at Sulphur Springs. Geochemical evidence indicates the temperature of the brine may exceed 250°C.

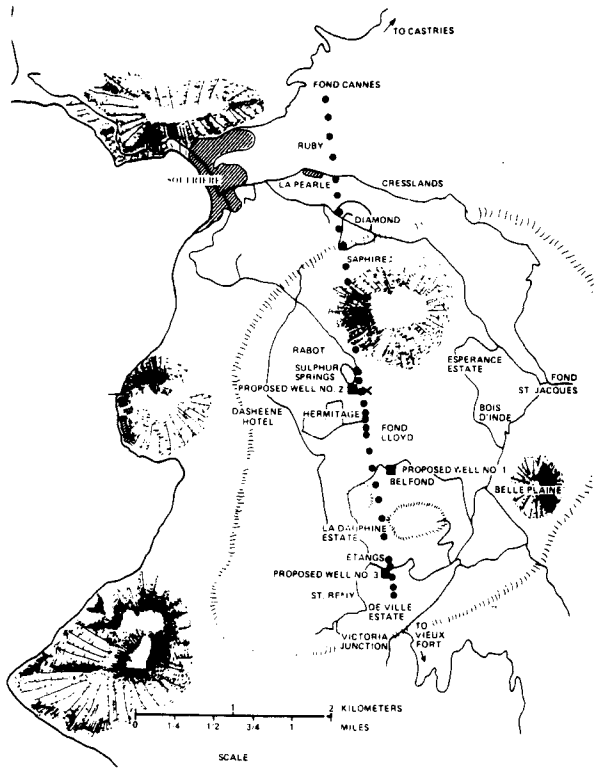

Fig. 1
Location of the 5.2-km-long resistivity profile line (containing 32 electrode stations) across the Qualibou caldera.

The recommended locations for exploratory drilling in Qualibou caldera are (Fig. 1):

(1) Craters of Belfond - Caldera-related faulting and recent phreatomagmatic volcanism indicate fracture permeability, and low resistivity suggests that geothermal brines occur at a depth of less than 1 km.

(2) Valley of Sulphur Springs - Hot springs and fumaroles, fluid chemical compositions, and low formation resistivity all indicate a geothermal brine reservoir about 2 km deep with the possibility of a hot dry steam field above the brine reservoir.

(3) Etangs - The southern caldera fault and a very low shallow resistivity suggest a reservoir of geothermal brine at a depth of about 1 km.

In summary, Qualibou caldera has excellent geothermal potential, and exploratory drilling should result in the discovery of a high-temperature brine reservoir. Geothermal brines (and perhaps dry steam) may be found at a depth of 1-2 km under the central and southern caldera area.

Field work on St. Lucia was completed within seven months of contract initiation, and in one year, detailed results were published in a series of Los Alamos Technical Reports (References 1-4). As a result of this assessment, U.S. AID and the U.N. Revolving Fund are providing over $5 million for drilling and testing to begin early in 1986. This money will go to the private sector, and at least $2.5 million must be contracted to U.S. firms.

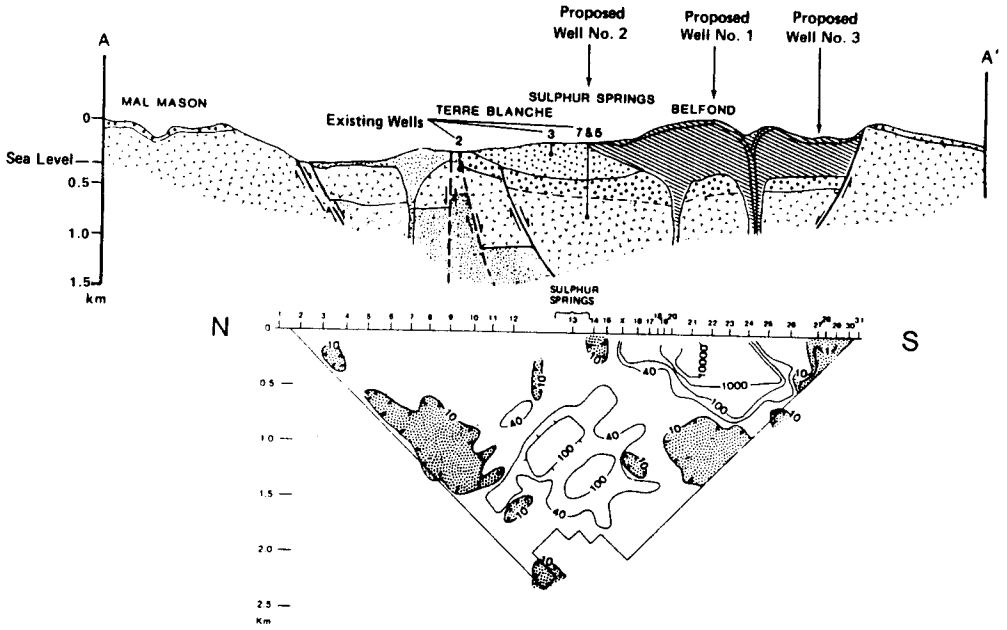

Fig. 2

Apparent resistivity data from the dipole-dipole survey plotted as a function of depth. Resistivity values are in ohm-m and are shown beneath the appropriate geologic cross section. Shaded areas depict resistivity contours of 10 ohm-m or less.

GEOTHERMAL ACTIVITIES IN CENTRAL AMERICA

Objectives - The long-term geothermal and assistance plan that is being formulated and implemented by Los Alamos and the U.S. Geological Survey is responsive to needs that were identified by scientists, engineers, and government officials from Central American countries. The plan is designed to

(1) Insure continued development of economical electricity derived from geothermal energy.

(2) Provide technical training to counterpart organizations for planning, operating, and maintaining geothermal plants.

Progress To Date - During the first six months of this project, reconnaissance geology and geochemistry studies were carried out at six geothermal sites in Honduras. Platanares, San Ignacio, and Azacualpa (Fig. 3) were selected for more detailed investigations, and these sites were examined by teams of Los Alamos/ENEE (Empresa Nacional de Energia Electrica) geologists, and emphasis was put on structural geology, stratigraphy, and detailed mapping of thermal springs.

Water samples were collected and analyzed from these sites by a joint Los Alamos/U.S. Geological Survey/ENEE team in order to estimate the subsurface temperatures of geothermal reservoirs. The samples are characterized by relatively high chloride waters having neutral to alkaline pH, characteristics that are typical of hot water-dominated geothermal systems. Estimates for subsurface geothermal reservoir temperatures are as follows: Platanares, 220°C; San Ignacio, 200°C; Azacualpa, 185°C; Pavana, 145°C; and El Olivar, 130°C.

Initial geothermal reconnaissance efforts in Costa Rica will center on the volcanic region surrounding the Miravalles geothermal development in Guanacaste Province.

Los Alamos personnel have overhauled a trailer-mounted well logging rig for interim use in the Miravalles geothermal wells, and logging is currently in progress. Temperatures up to 235°C have been measured. Measurements being made include pressure and temperature as a function of depth, wellbore diameter and contour, and fluid velocity in the wellbore. Samples of the geothermal reservoir fluid have been obtained. The presence of wellbore scaling in one production well, which was suspected by ICE (Instituto Costarricense De Electricidad) engineers, was verified.

The specifications for a self-contained well logging truck have been written, and the procurement process has begun. This truck will remain in Central America. It will have on board electric and hydraulic systems, a 3,000 m high-temperature logging cable, and all necessary equipment for logging geothermal wells in remote areas, including a selection of high-temperature downhole logging tools.

Fabrication of a high-output DC electrical resistivity system is nearing completion. This unit, similar to the system that was used on St. Lucia, will remain in Central America to support geophysical exploration activities. It will be used first in Honduras.

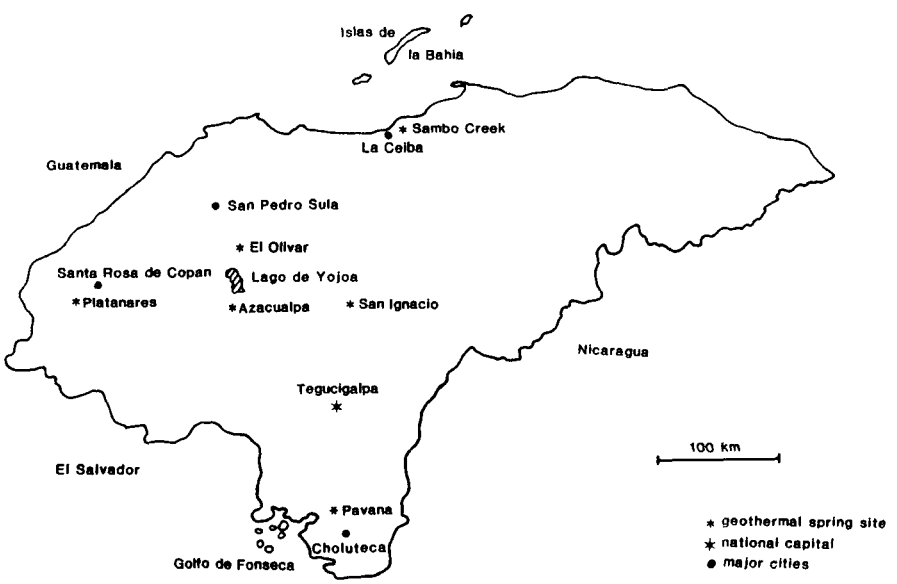

Fig. 3
Honduras Geothermal Prospects

GEOTHERMAL NEEDS OF CENTRAL AMERICA

Honduras - Before 1990, ENEE must make decisions on how to meet Honduras' growing electricity demands. ENEE has requested an assessment of the technical feasibility of geothermal power plants in Honduras and the most desirable locations for development. Thus, an extensive geothermal reconnaissance effort is now underway. After completing electrical geophysics measurements and drilling shallow temperature gradient wells, a site will be selected for drilling production wells. The production testing data from these wells will confirm (or deny) the reservoir potential of the site and provide ENEE with the information required to determine its future policy.

Costa Rica - With the Miravalles geothermal field undergoing active development, the most urgent need of ICE is for equipment and technical expertise to perform well logging measurements in the production wells. The measurements that have been given highest priority include well temperature surveys, pressure surveys, flow measurements to determine which horizons are producing the geothermal fluids, casing profile measurements to check for casing damage and wellbore scale accumulations, obtaining samples of the pressurized reservoir fluids for geochemical analysis, cement bond log surveys to assess the integrity of the bond between the casing and the formation, and reservoir interference tests for estimating the production capacity of the geothermal reservoir.

In addition to Miravalles, other regions within Costa Rica appear to have significant geothermal energy potential. The most promising of these regions will be identified as part of this program.

El Salvador - Electricity production from the Ahuachapan geothermal power plant has been declining steadily during recent years. The most urgent need of CEL (Comision Ejecutiva Hydroelectrica del Rio Lempa) is to reverse this trend and bring the plant back to its previous level of production. CEL has identified two probable causes: declining reservoir pressure because geothermal fluids are not reinjected into the reservoir, and mechanical damage in otherwise good production wells. CEL needs well logging measurements and reservoir engineering expertise to devise a plan for solving these problems and improving well production.

Adjacent to Ahuachapan is an undeveloped geothermal area at Chipilapa. CEL has requested equipment and personnel to conduct geophysical exploration activities to identify the geothermal reservoir and target the most promising production well locations.

Guatemala - The most urgent need of INDE (Instituto Nacional de Electrificacion) at the Zunil geothermal field is for equipment and technical expertise to log production wells. INDE has placed particular importance on cement bond logging because the wells are very hot, and production casings were cemented in place using conventional moderate-temperature cement. INDE would also like to have "tracer" tests performed to determine the communication between production wells through the geothermal reservoir.

INDE has also requested assistance in understanding the geology, hydrogeochemistry, and geophysics of the Amatitlan geothermal region.

Panama - The Valle de Anton region is currently being examined by IRHE (Instituto de Recursos Hidraulicos y Electrificacion) as a potential geothermal energy development site. IRHE has requested assistance in conducting a hydrogeochemical reconnaissance of the area. Emphasis will be placed on geochemical thermometry to determine if a sufficiently high-temperature reservoir exists in this region.

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